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SURFACE RESISTANCE OF $YBa_2Cu_3O_7$ FILMS DEPOSITED ON $LaGaO_3$ SUBSTRATES

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Superconducting films of $YBa_2Cu_3O_7$ deposited onto $LaGaO_3$ substrates were prepared by e-beam and magnetron sputtering techniques. Surface resistance measurements made at 22 GHz, 86 GHz, and 148 GHz show that these films are superior to those deposited by similar techniques onto $SrTiO_3$. Typical surface resistance values measured at 22 GHz and 12 K are ~2 mΩ with the lowest value being 0.2 mΩ, which is only 2-4 times higher than Nb. The surface resistance is proportional to the square of the measuring frequency.

1. INTRODUCTION

Surface resistance (R_s) measurements on high-temperature superconductors are necessary to determine their suitability for practical applications.[1] Several measurements of R_s for films of $YBa_2Cu_3O_7$ (YBCO) on $SrTiO_3$ have been made at various frequencies and temperatures.[2-3] $SrTiO_3$ is not the best substrate for high-frequency applications because of its high dielectric constant. A more suitable substrate is $LaGaO_3$.

2. EXPERIMENTAL

Thin films (0.5-0.8 μm) of YBCO were deposited onto single-crystal (001) $LaGaO_3$ substrates by either e-beam or magnetron sputtering techniques. X-ray diffraction data showed that the films were highly c-axis and a-axis oriented with only trace amounts of impurities. Pole-figure analyses of selected films showed that all films were well aligned with the single-crystal substrate.

Surface resistance measurements were made at three frequencies (22 GHz, 86 GHz, and 148 GHz) as a function of temperature using the same experimental technique. In each case the end wall of a cylindrical cavity (TE_{01n} mode family) was replaced by the superconducting sample. R_s is computed from the difference in Q values of the bare cavity and the cavity with the superconducting end wall.

3. RESULTS

Shown in Fig. 1 are typical surface-resistance curves for films of YBCO e-beam deposited onto $SrTiO_3$ and $LaGaO_3$ measured in a Cu cavity at 22 GHz. The data are plotted as log R_s vs. T_c/T (T_c = 90 K). For this measurement the sensitivity of the Cu cavity is ~ 2 mΩ; thus the 1 mΩ value shown in the graph is only an upper limit. Utilizing a Nb superconducting cavity, R_s was re-measured at 4 K and 22 GHz and found to be 0.2 ± 0.1 mΩ, which is only a factor of 2-4 higher than Nb.

Figure 2 shows R_s vs. T data measured at three different frequencies for a YBCO film deposited onto $LaGaO_3$ by magnetron sputtering. The frequency dependence of these data is given in Fig. 3 for T = 70 K and 30 K. The best fit gives $R_s \propto \omega^n$ with n = 2.06 ± 0.14 and 2.02 ± 0.47, respectively. This quadratic dependence is

consistent both with BCS theory and with experimental measurements on conventional superconductors.

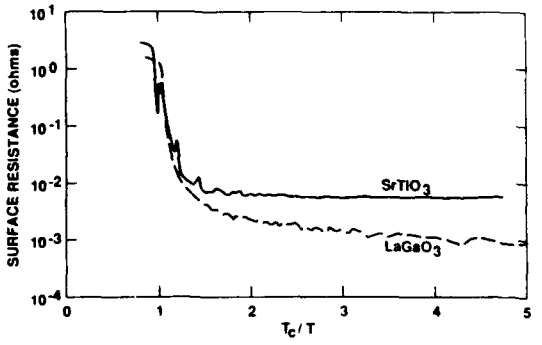

FIGURE 1. R_S vs. reduced temperature (T_C = 90 K) for 0.8-μm films of YBCO deposited onto $SrTiO_3$ and $LaGaO_3$ substrates.

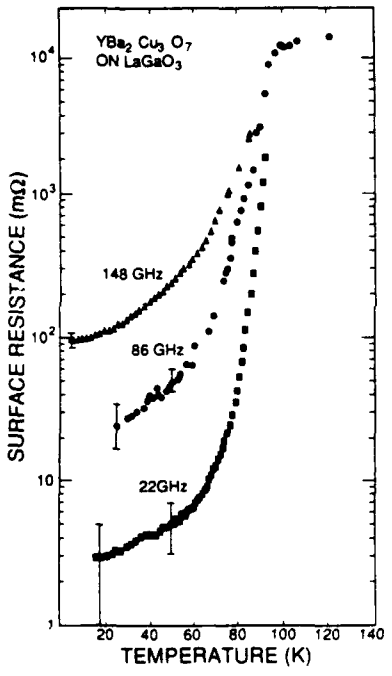

FIGURE 2. R_S vs. T for a 0.5-μm film of YBCO deposited onto a $LaGaO_3$ substrate.

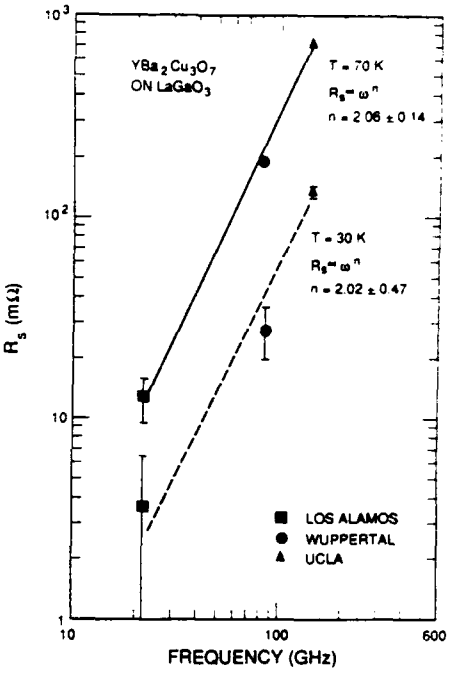

FIGURE 3. Frequency dependence of R_S taken from the data shown in Fig. 2.

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